



## Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact [support@jstor.org](mailto:support@jstor.org).

## ON THE SKELETON OF REGENERATED ANTERIOR LIMBS IN THE FROG.

ESTHER F. BYRNES.

While the skeletal structures of regenerated posterior limbs in the Anura have been found to be capable of almost complete restoration, I know of no similar studies on the anterior limbs. As the anterior limbs of Anurous batrachians appear relatively late in the life of the larvæ, some interest attaches to the power of regeneration possessed by these organs.

That the lost *regions* of the anterior limbs may be restored more or less completely has already been proven,<sup>1</sup> but how completely the *skeleton* can be restored within the various limb-regions it is the purpose of this article to show. The many less complete instances of regeneration which are of frequent occurrence after amputation of the anterior limb have been omitted from consideration.

A comparison of the regenerated skeletons seen in Figs. 2 and 3 with the normal skeleton figured in 1 shows that the skeletal structures are often less completely regenerated than might be expected from the outward appearance of the limb. In both cases there is a tendency not only to reduction in the number of digits in the regenerated hands, but also to a reduction in the number of phalanges in each digit.

The relatively greater length of the middle digit in both 2 and 3 marks it as undoubtedly the fourth digit, though in each case but three phalanges are present, while in the normal limb there are four. A similar reduction of parts likewise occurs in the fifth digit of both 2 and 3 which normally is also composed of four phalanges. In the case of the remaining digit in the regenerated hands, I am unable to determine whether it is the third or the second digit that has regenerated. In Fig. 2 the digit contains the normal number of phalanges, whether it be

<sup>1</sup> Byrnes, E. F., "Regeneration of the Anterior Limbs in the Tadpoles of Frogs." *Archiv für Entwicklungsmechanik der organismen*. Bd. XVIII., 2 Heft, 1904.

the third or the second. In Fig. 3 this digit has suffered a reduction in its parts along with the fourth and fifth, and in its relatively short length suggests the third digit, while the relatively greater length of the corresponding digit in 2 suggests that it may be the second. In both 2 and 3 the rudimentary pollyx is present. In the carpal region there is but little differentiation in

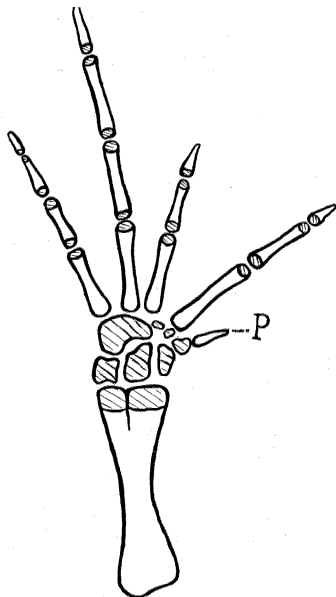


FIG. 1. The skeleton of a regenerated hand.

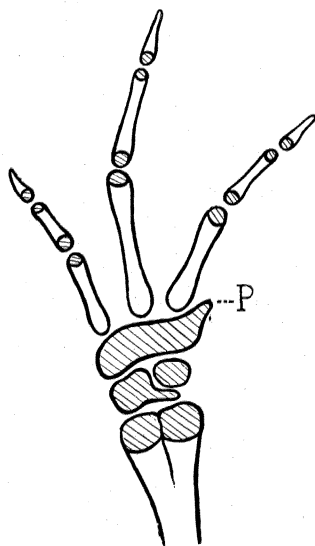


FIG. 2. A normal skeleton of an anterior forearm and hand. The striped are as are cartilaginous.

the regenerated limbs, there being but little ossification in the cartilage in 2, and no ossification whatever in the carpal region of 3.

A striking feature in the regenerated limbs is the constant appearance of the rudimentary pollyx. Sometimes this is represented by a separate cartilaginous structure as in Fig. 3, while in other cases it is a mere projection from the fused cartilaginous carpalia, as in Fig. 2. Even in hands that are greatly reduced and distorted after regeneration, the cartilaginous projection of the pollyx often persists, as in Fig. 4.

After regeneration the double nature of the radio-ulnare is invariably strongly marked by a deep groove showing the line of demarkation between the ulnar and the radial regions. There is no trace of where the amputation occurred, the regenerated end being perfectly normal in proportion, and showing complete continuity with the upper part of the bone.

While the frog larvæ were regenerating the imperfect limbs whose skeletal structures are shown in the text figures, similar experiments were made on some *Amblystoma* larvæ about three

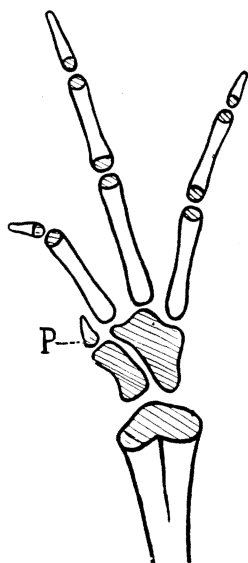


FIG. 3. The skeleton of a regenerated hand.

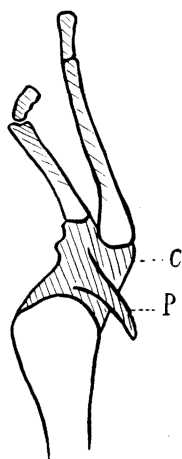


FIG. 4. The skeleton of a partly regenerated anterior hand. *P*, the pollyx ; *C*, the carpus.

months old. As soon as an *Amblystoma* had regenerated the lost limb, the regenerated limb was again amputated, so that toward the close of the experiments, the *Amblystomæ* were in possession of perfectly formed limbs, after having regenerated five in rapid succession. Each of the five limbs was not only normal in form and in the number of its parts, but it was also normal in *size*, the larvæ apparently having suffered no loss of power, even temporarily, to completely recover from the injury.

Early observers<sup>1</sup> have shown that in the Urodeles, the second digit is the first to appear in the process of regeneration, then the first, and subsequently the third and fourth digits. More recently, Ridewood has recorded a similar sequence in the development of the regenerated digits of the posterior limb of the midwife toad.

The concealed position of the anterior limb in the gill-chamber in the frog, makes the observation of sequence in the development of the digits difficult; but in the anterior limb, that region which appears first in the posterior limb of the toad and of the Urodele, is the one that in the frog is often wholly lacking.

Ridewood<sup>2</sup> has figured a case of regeneration in the skeleton of the posterior limb of the toad that shows that the limb is inherently capable of *complete* regeneration, and doubtless regeneration of the anterior limb may be much more complete in the frog than would appear from Figs. 2 and 3. Inasmuch, however, as these figures illustrate regeneration after amputation of the anterior limb when it was but very imperfectly formed, they indicate a marked tendency toward early loss of regenerative power.

BROOKLYN, NEW YORK,  
March, 1904.

<sup>1</sup> Götte, A., "Ueber Entwicklung und Regeneration des Gliedmassenskelets der Molche." Leipzig, 1879.

Strasser, "Zur Entwicklung der Extremitätenknorpel bei Salamandern und Tritonen. *Morph. Jahrb.*, Bd. V., Leipzig, 1879.

<sup>2</sup> Ridewood, W. G., "On the Skeleton of Regenerated Limbs of the Midwife Toad (*Alytes obstetricans*)."  
*Proceedings of the Zoölogical Society of London*, Feb. 15, 1898.